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Title: My Journey to Plutonium Casting Operations at LANL

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My Journey to Plutonium Casting Operations at LANL

Presentation to Summer Physics Camp for
Young Women

Meagan Wheeler

TBD

Who am I?

- I grew up in Nambe and attended Pojoaque Valley Schools from 5th grade until I graduated high school
- Growing up in Northern New Mexico made me realize I love being outside I frequently went:
 - Camping
 - Hiking
 - Hunting



Figure 1: Camping with my dog Levie.



Figure 2: Hiking with my best friend in Sedona, Arizona.



Figure 3: Hunting with my father, uncle, and cousins.

How did I get interested in STEM?

- It started with a science class in middle school
 - I was interested in the scientific method and the process of designing an experiment
- In high school I took chemistry it was challenging.
 - I was the kind of girl that if something was difficult I desired to learn more so....
- I majored in Chemistry at Northern Arizona University
 - I was working with designers at LANL, however, so I decided to minor in mechanical engineering
 - These two degrees felt like they fit me well but...
- I decided I hadn't had enough and went to Colorado School of Mines to complete my Masters of Engineering in Metallurgical and Materials Engineering.

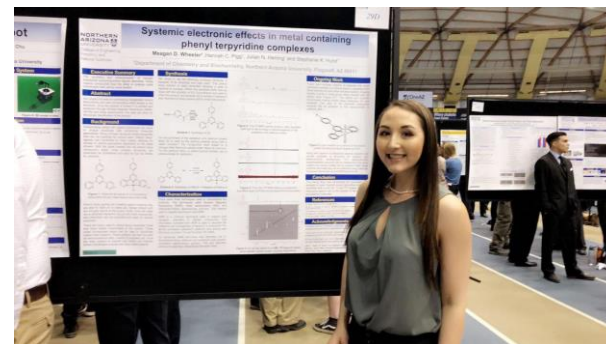


Figure 4: Undergraduate research symposium.

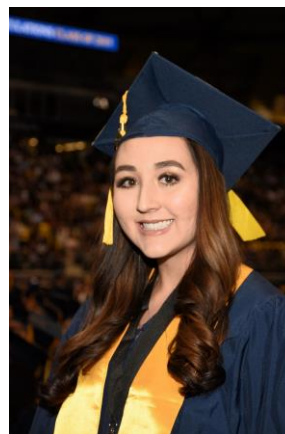


Figure 5: Graduation from Northern Arizona University.



Figure 6: Graduation from Colorado School of Mines.

What on earth is Metallurgical Engineering?

- Metallurgy is the study of the properties of metals and how they are produced.
 - This is the study of the physical properties, how they are extracted and where they come from (how they're formed)
 - There are a lot of aspects of chemistry and mechanical engineering in metallurgical engineering depending on the area or material
- So metallurgical engineering is producing metals that can be used for various applications.
 - Focus areas / industries that metallurgists go into are:
 1. Medical Devices - Implants (pacemakers, hips, knees etc.), Stints, Prosthetics
 2. Electronics
 3. Space Exploration



Figure 7: Worker casting a metallic material.¹

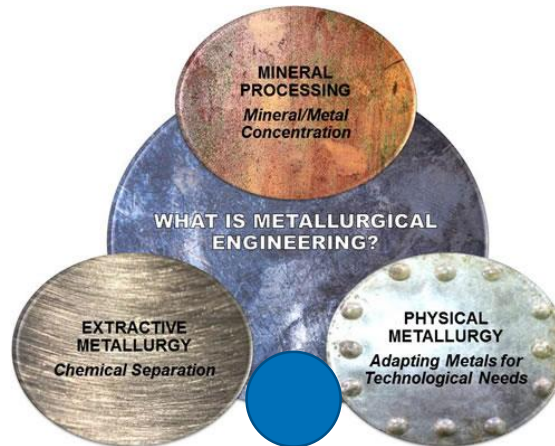


Figure 8: Diagram explaining metallurgical engineering.²



Figure 9: Metal being cast into molds.³

(1) http://content.time.com/time/specials/packages/article/0,28804,2073703_2073653_2073697,00.html

(2) <https://mineslife.wordpress.com/2015/02/12/metallurgical-engineering-what-is-it/>

(3) <https://www.aboriginalaccess.ca/adults/types-of-engineering/metallurgical>

Plutonium Casting

- So what do I work on?
 - I'm a metallurgist in a (actinide) foundry that melts and casts nuclear materials
- Plutonium is a strange material to work with and offers a variety of challenges
 1. Work needs to be performed in gloveboxes (Figure 4)
 2. Negative pressure needs to be maintained throughout the facility

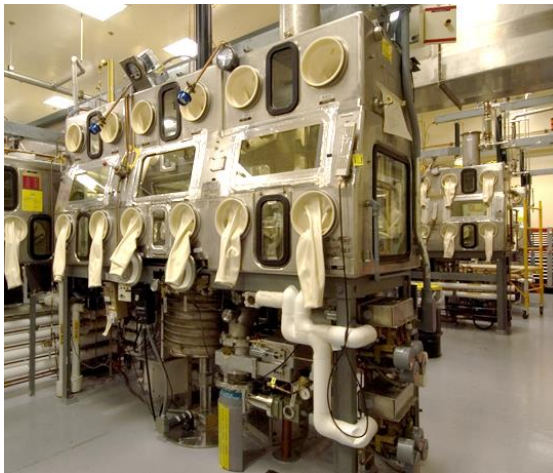


Figure 10: Model of vacuum induction furnace.



Figure 11: Glovebox worker.⁴

Periodic Table of the Elements

<div>Atomic Number →</div> <div>Symbol ←</div> <div>Name →</div> <div>Electrons per shell →</div> <div>Atomic Weight ←</div>																												<div>13 IIIA</div> <div>Boron</div> <div>14 IVA</div> <div>Carbon</div> <div>15 VA</div> <div>Nitrogen</div> <div>16 VIA</div> <div>Oxygen</div> <div>17 VIIA</div> <div>Fluorine</div> <div>18 VIIIA</div> <div>Neon</div>																	
<div>1 IA</div> <div>H</div> <div>Hydrogen</div> <div>1.008</div> <div>1</div> <div>2 IIA</div> <div>Be</div> <div>Beryllium</div> <div>9.012</div> <div>4</div> <div>3</div> <div>Li</div> <div>Lithium</div> <div>6.941</div> <div>3</div> <div>11</div> <div>Na</div> <div>Sodium</div> <div>22.990</div> <div>11</div> <div>12</div> <div>Mg</div> <div>Magnesium</div> <div>24.305</div> <div>12</div> <div>19</div> <div>K</div> <div>Potassium</div> <div>39.098</div> <div>19</div> <div>20</div> <div>Ca</div> <div>Calcium</div> <div>40.078</div> <div>20</div> <div>37</div> <div>Rb</div> <div>Rubidium</div> <div>85.468</div> <div>37</div> <div>38</div> <div>Sr</div> <div>Strontium</div> <div>87.62</div> <div>38</div> <div>55</div> <div>Cs</div> <div>Cesium</div> <div>132.905</div> <div>55</div> <div>56</div> <div>Ba</div> <div>Barium</div> <div>137.327</div> <div>56</div> <div>87</div> <div>Fr</div> <div>Francium</div> <div>223</div> <div>88</div> <div>Ra</div> <div>Radium</div> <div>226</div>																												<div>3 IIIB</div> <div>Scandium</div> <div>4 IVB</div> <div>Titanium</div> <div>5 VB</div> <div>Vanadium</div> <div>6 VIB</div> <div>Chromium</div> <div>7 VIIB</div> <div>Manganese</div> <div>8 VIIIB</div> <div>Iron</div> <div>9 VIIIB</div> <div>Cobalt</div> <div>10 VIIIB</div> <div>Nickel</div> <div>11 IB</div> <div>Copper</div> <div>12 IIB</div> <div>Zinc</div> <div>13</div> <div>Al</div> <div>Aluminum</div> <div>14</div> <div>Si</div> <div>Silicon</div> <div>15</div> <div>P</div> <div>Phosphorus</div> <div>16</div> <div>S</div> <div>Sulfur</div> <div>17</div> <div>Cl</div> <div>Chlorine</div> <div>18</div> <div>Ar</div> <div>Argon</div>																	
<div>State of matter (color of name)</div> <div>GAS LIQUID SOLID UNKNOWN</div> <div>Subcategory in the metal-metalloid-nonmetal trend (color of background)</div> <div>Alkali metals Alkaline earth metals Transition metals Lanthanides Actinides Metalloids Reactive nonmetals Noble gases Unknown chemical properties</div>																																													
<div>21</div> <div>Sc</div> <div>Scandium</div> <div>44.956</div> <div>21</div> <div>22</div> <div>Ti</div> <div>Titanium</div> <div>47.88</div> <div>22</div> <div>23</div> <div>V</div> <div>Vanadium</div> <div>50.942</div> <div>23</div> <div>24</div> <div>Cr</div> <div>Chromium</div> <div>51.996</div> <div>24</div> <div>25</div> <div>Mn</div> <div>Manganese</div> <div>54.938</div> <div>25</div> <div>26</div> <div>Fe</div> <div>Iron</div> <div>55.845</div> <div>26</div> <div>27</div> <div>Co</div> <div>Cobalt</div> <div>58.933</div> <div>27</div> <div>28</div> <div>Ni</div> <div>Nickel</div> <div>58.693</div> <div>28</div> <div>29</div> <div>Cu</div> <div>Copper</div> <div>63.546</div> <div>29</div> <div>30</div> <div>Zn</div> <div>Zinc</div> <div>65.38</div> <div>30</div> <div>31</div> <div>Ga</div> <div>Gallium</div> <div>69.723</div> <div>31</div> <div>32</div> <div>Ge</div> <div>Germanium</div> <div>72.63</div> <div>32</div> <div>33</div> <div>As</div> <div>Arsenic</div> <div>74.922</div> <div>33</div> <div>34</div> <div>Se</div> <div>Selenium</div> <div>78.96</div> <div>34</div> <div>35</div> <div>Br</div> <div>Bromine</div> <div>79.904</div> <div>35</div> <div>36</div> <div>Kr</div> <div>Krypton</div> <div>83.798</div> <div>36</div>																												<div>39</div> <div>Y</div> <div>Yttrium</div> <div>88.906</div> <div>39</div> <div>40</div> <div>Zr</div> <div>Zirconium</div> <div>91.224</div> <div>40</div> <div>41</div> <div>Nb</div> <div>Niobium</div> <div>92.906</div> <div>41</div> <div>42</div> <div>Mo</div> <div>Molybdenum</div> <div>95.94</div> <div>42</div> <div>43</div> <div>Tc</div> <div>Technetium</div> <div>98</div> <div>43</div> <div>44</div> <div>Ru</div> <div>Ruthenium</div> <div>101.07</div> <div>44</div> <div>45</div> <div>Rh</div> <div>Rhodium</div> <div>102.91</div> <div>45</div> <div>46</div> <div>Pd</div> <div>Palladium</div> <div>106.42</div> <div>46</div> <div>47</div> <div>Ag</div> <div>Silver</div> <div>107.87</div> <div>47</div> <div>48</div> <div>Cd</div> <div>Cadmium</div> <div>112.41</div> <div>48</div> <div>49</div> <div>In</div> <div>Indium</div> <div>114.82</div> <div>49</div> <div>50</div> <div>Sn</div> <div>Tin</div> <div>118.71</div> <div>50</div> <div>51</div> <div>Sb</div> <div>Antimony</div> <div>121.76</div> <div>51</div> <div>52</div> <div>Te</div> <div>Tellurium</div> <div>127.6</div> <div>52</div> <div>53</div> <div>I</div> <div>Iodine</div> <div>126.91</div> <div>53</div> <div>54</div> <div>Xe</div> <div>Xenon</div> <div>131.29</div> <div>54</div>																	
<div>72</div> <div>Hf</div> <div>Hafnium</div> <div>178.49</div> <div>72</div> <div>73</div> <div>Ta</div> <div>Tantalum</div> <div>180.948</div> <div>73</div> <div>74</div> <div>W</div> <div>Tungsten</div> <div>183.84</div> <div>74</div> <div>75</div> <div>Re</div> <div>Rhenium</div> <div>186.207</div> <div>75</div> <div>76</div> <div>Os</div> <div>Osmium</div> <div>190.23</div> <div>76</div> <div>77</div> <div>Ir</div> <div>Iridium</div> <div>192.22</div> <div>77</div> <div>78</div> <div>Pt</div> <div>Platinum</div> <div>195.084</div> <div>78</div> <div>79</div> <div>Au</div> <div>Gold</div> <div>196.967</div> <div>79</div> <div>80</div> <div>Hg</div> <div>Mercury</div> <div>200.59</div> <div>80</div> <div>81</div> <div>Tl</div> <div>Thallium</div> <div>204.38</div> <div>81</div> <div>82</div> <div>Pb</div> <div>Lead</div> <div>207.2</div> <div>82</div> <div>83</div> <div>Bi</div> <div>Bismuth</div> <div>208.98</div> <div>83</div> <div>84</div> <div>Po</div> <div>Polonium</div> <div>209</div> <div>84</div> <div>85</div> <div>At</div> <div>Astatine</div> <div>210</div> <div>85</div> <div>86</div> <div>Rn</div> <div>Radon</div> <div>222</div> <div>86</div>																												<div>104</div> <div>Rf</div> <div>Rutherfordium</div> <div>261</div> <div>104</div> <div>105</div> <div>Db</div> <div>Dubnium</div> <div>262</div> <div>105</div> <div>106</div> <div>Sg</div> <div>Seaborgium</div> <div>266</div> <div>106</div> <div>107</div> <div>Bh</div> <div>Bohrium</div> <div>264</div> <div>107</div> <div>108</div> <div>Hs</div> <div>Hassium</div> <div>277</div> <div>108</div> <div>109</div> <div>Mt</div> <div>Meitnerium</div> <div>268</div> <div>109</div> <div>110</div> <div>Ds</div> <div>Darmstadtium</div> <div>271</div> <div>110</div> <div>111</div> <div>Rg</div> <div>Roentgenium</div> <div>272</div> <div>111</div> <div>112</div> <div>Cn</div> <div>Copernicium</div> <div>285</div> <div>112</div> <div>113</div> <div>Nh</div> <div>Nihonium</div> <div>284</div> <div>113</div> <div>114</div> <div>Fl</div> <div>Flerovium</div> <div>289</div> <div>114</div> <div>115</div> <div>Mc</div> <div>Moscovium</div> <div>288</div> <div>115</div> <div>116</div> <div>Lv</div> <div>Livermorium</div> <div>293</div> <div>116</div> <div>117</div> <div>Ts</div> <div>Tennessine</div> <div>289</div> <div>117</div> <div>118</div> <div>Og</div> <div>Oganesson</div> <div>294</div> <div>118</div>																	
<div>57</div> <div>La</div> <div>Lanthanum</div> <div>138.905</div> <div>57</div> <div>58</div> <div>Ce</div> <div>Cerium</div> <div>140.12</div> <div>58</div> <div>59</div> <div>Pr</div> <div>Praseodymium</div> <div>140.908</div> <div>59</div> <div>60</div> <div>Nd</div> <div>Neodymium</div> <div>144.24</div> <div>60</div> <div>61</div> <div>Pm</div> <div>Promethium</div> <div>145</div> <div>61</div> <div>62</div> <div>Sm</div> <div>Samarium</div> <div>150.36</div> <div>62</div> <div>63</div> <div>Eu</div> <div>Europium</div> <div>151.964</div> <div>63</div> <div>64</div> <div>Gd</div> <div>Gadolinium</div> <div>157.25</div> <div>64</div> <div>65</div> <div>Tb</div> <div>Terbium</div> <div>158.925</div> <div>65</div> <div>66</div> <div>Dy</div> <div>Dysprosium</div> <div>162.50</div> <div>66</div> <div>67</div> <div>Ho</div> <div>Holmium</div> <div>164.930</div> <div>67</div> <div>68</div> <div>Er</div> <div>Erbium</div> <div>167.259</div> <div>68</div> <div>69</div> <div>Tm</div> <div>Thulium</div> <div>168.930</div> <div>69</div> <div>70</div> <div>Yb</div> <div>Ytterbium</div> <div>173.054</div> <div>70</div> <div>71</div> <div>Lu</div> <div>Lutetium</div> <div>174.967</div> <div>71</div>																												<div>89</div> <div>Ac</div> <div>Actinium</div> <div>227</div> <div>89</div> <div>90</div> <div>Th</div> <div>Thorium</div> <div>232.038</div> <div>90</div> <div>91</div> <div>Pa</div> <div>Protactinium</div> <div>231.036</div> <div>91</div> <div>92</div> <div>U</div> <div>Uranium</div> <div>238.029</div> <div>92</div> <div>93</div> <div>Np</div> <div>Neptunium</div> <div>237.048</div> <div>93</div> <div>94</div> <div>Pu</div> <div>Plutonium</div> <div>244.064</div> <div>94</div> <div>95</div> <div>Am</div> <div>Americium</div> <div>243.061</div> <div>95</div> <div>96</div> <div>Cm</div> <div>Curium</div> <div>247.07</div> <div>96</div> <div>97</div> <div>Bk</div> <div>Berkelium</div> <div>247.07</div> <div>97</div> <div>98</div> <div>Cf</div> <div>Californium</div> <div>251.08</div> <div>98</div> <div>99</div> <div>Es</div> <div>Einsteinium</div> <div>252.083</div> <div>99</div> <div>100</div> <div>Fm</div> <div>Fermium</div> <div>257.10</div> <div>100</div> <div>101</div> <div>Md</div> <div>Mendelevium</div> <div>258.10</div> <div>101</div> <div>102</div> <div>No</div> <div>Nobelium</div> <div>259.10</div> <div>102</div> <div>103</div> <div>Lr</div> <div>Lawrencium</div> <div>262.10</div> <div>103</div>																	

Plutonium Casting

- Plutonium is processed in a vacuum induction furnace (Figure 5)
 - How does this work?
- Induction Furnace Explanation

<https://www.youtube.com/watch?v=RgFEiRu7sUM>



Figure 12: Images of casting operations inside glovebox.

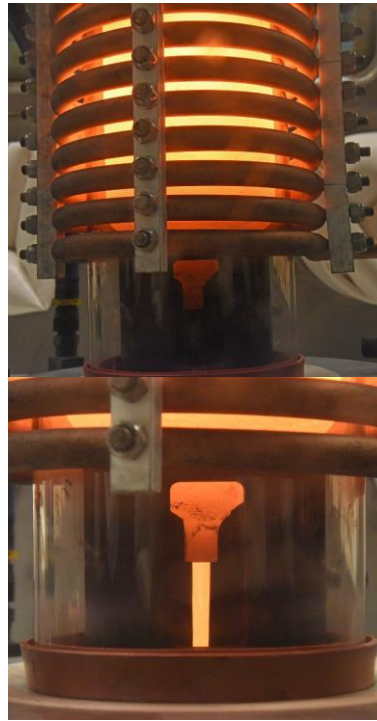


Figure 13: Images of casting operations.

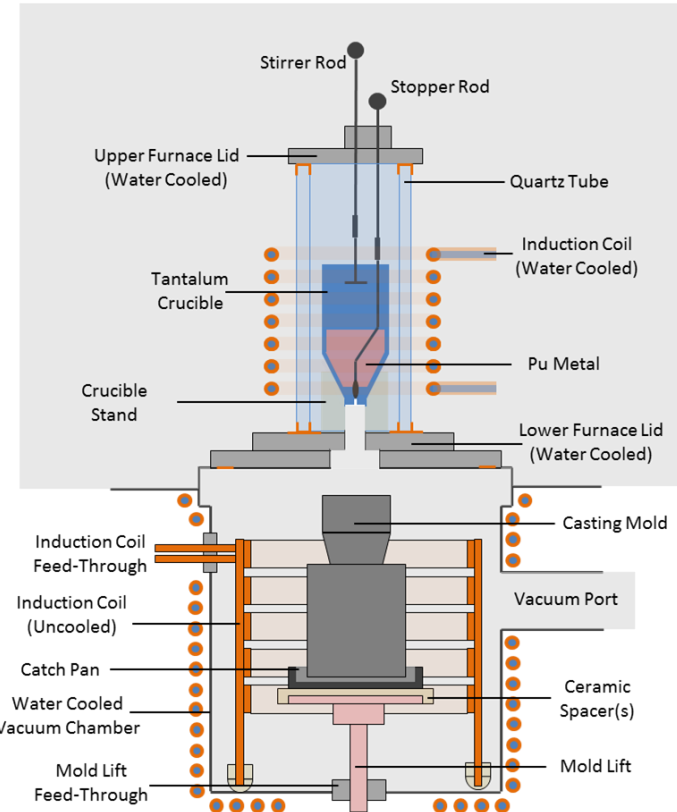


Figure 14: Model of induction furnace.

Casting Material and Product

- The casting process begins with a ring of plutonium that is broken down and placed into the induction furnace
- The next step is to cast rods which are easier to work with than the starting material
- So after the casting operations are completed what are we left with?
 - The final casting product is the puck



Figure 15: Plutonium ring.

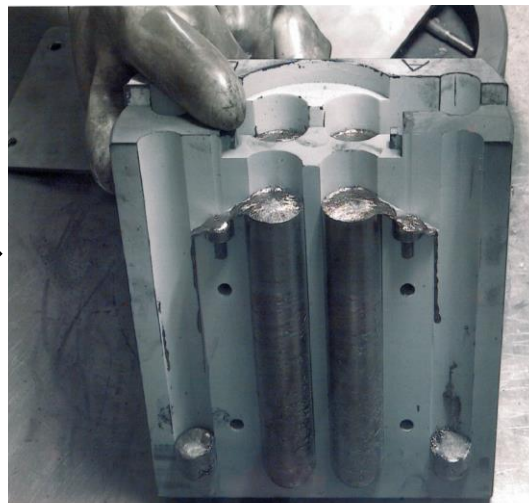


Figure 16: Recast plutonium metal rods.

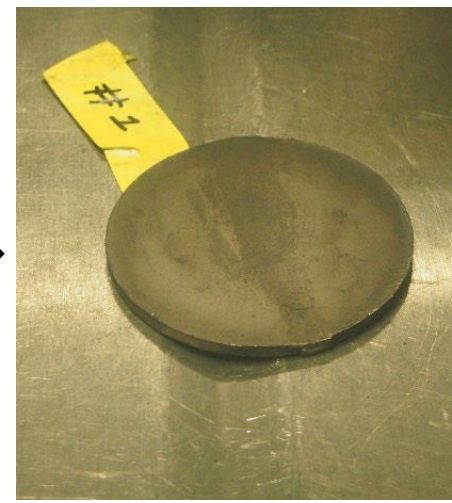
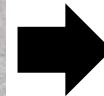


Figure 17: Final cast plutonium puck.

Casting Videos

- Bronze casting using the lost wax process

https://www.youtube.com/watch?v=D2LTsD8IE_s

- Sand casting video

https://www.youtube.com/watch?v=WXx_KguZTC4&t=3s

- Large scale steel casting

https://www.youtube.com/watch?v=WXx_KguZTC4&t=3s

Questions?